

Toxic Substances from Coal Energy: An Overview

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Environmental concerns over increased coal consumption are fully justified by the past history of coal use. Although improved technology has provided some safeguards, increased utilization will require mining practices, emission control technologies, and waste disposal procedures that are not yet fully integrated into the routine use of the coal energy system.

The Committee on Health and Environmental Effects of Increased Coal Utilization identified six critical environmental issues which are of concern: coal mine worker health and safety, reclamation of arid lands from surface mining, the health effects of coal combustion products, toxic trace elements in coal combustion wastes, acid fallout, and global effects of carbon dioxide in the atmosphere. This presentation addresses the first four of these issues.

In its National Energy Plan of 1977, the Carter Administration proposed a significant increase in the use of coal, the most abundant fossil fuel in the U.S. Under the energy plan, coal consumption will reach 1.2 million tons by 1985, nearly double the total consumption in 1978. But even in the absence of an energy plan, economic and supply considerations would be expected to bring about an increase in coal consumption to one million tons by 1985. Thus there is little reason to doubt that within the next 7 to 10 years substantial amounts of coal will be mined and combusted, above current rates of consumption.

At the same time, coal is a dirty fuel. Its potential for damage to health and the environment is greater than for oil or natural gas, considering the entire fuel cycle from extraction, transport and processing to combustion and waste disposal. Overall, coal is simply harder to handle and dirtier than oil or natural gas.

Environmental concerns over increased coal consumption are fully justified by the past history of coal use, from the beginning of the industrial revolution in England and the U.S. to the decades of the 1950's and 1960's. Exploitation of miners, mine disasters, black lung disease, strip mining, air pollution episodes, acid rain, blackened cities, and blackened lungs of the cities' inhabitants are only among the

more obvious health and environmental burdens imposed on industrialized society by the uncontrolled use of coal. Many of these environmental hazards are now well controlled, some nearly eliminated. Improved technology, industry practices, and federal legislation have together provided safeguards for miners, for restoration of coal stripped land, for removal of air pollutants from stack emissions, and for disposal of wastes. One very apparent result of the series of federal laws enacted since 1970 is that coal can never again be handled as cheaply and carelessly as it was in the first half of this century.

Increased utilization of coal during the next several decades will require mining practices, emission control technologies and waste disposal procedures that are not yet fully integrated into the routine of the coal energy system. While we possess the technological know-how to use coal in an environmentally acceptable manner, we have not accumulated the years of experience required to make the system work efficiently and smoothly. Initially, environmental control costs will be high, and delays in system operation will be many.

Environmental Constraints of Increased Coal Use

A recent report of a federally appointed Committee on Health and Environmental Effects of Increased Coal Utilization chaired by David Rall

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(dated December 23, 1977) identified six environmental issues "which urgently need resolution if we are to minimize undesirable consequences of increase coal utilization now, and in the future." The issues are: coal mine worker health and safety, reclamation of arid lands from surface mining, the health effects of coal combustion products, toxic trace elements in coal combustion, acid fallout, and global effects of CO₂ in the atmosphere.

While there are other environmental concerns associated with increased coal use, e.g., acid mine drainage, thermal pollution, competition for scarce water resources, and land use considerations, these six issues contain more uncertainties than most others and, because of the uncertainties, will be likely to generate the most controversy as the U.S. moves more vigorously towards the coal alternative. In this paper, I will address the first four of these issues in some detail.

Coal Mine Worker Health and Safety

The problem here is largely limited to underground mining. Over the past 30 years, there has been considerable improvement in the safety experience of the coal mining industry which, nevertheless, is still one of the most hazardous with respect to accident rates. Mining fatalities have shown a steady decline, both in absolute numbers and in fatal accidents per million tons of coal mined, since the 1930's. Part of this decline is attributable to the increased proportion of coal extracted by surface mining, but even in underground mining, improved mine ventilation and mining technologies have resulted in considerably fewer fatal and nonfatal accidents per man-hour and per million tons mined. However there is a tenfold or greater difference in accident rates underground between well established, steady mines and less experienced, short-lived mines. A rapid escalation in underground mining that results in recruitment of inexperienced miners and foreman and opening of mines by inexperienced operators could easily result in several disasters that could evoke a public outcry and demands for more restrictive legislation. Adequate training of inexperienced miners and careful planning of coal mine expansion are essential to prevent these undesirable outcomes.

Concerning miner health, coal worker's pneumoconiosis (black lung) is a chronic disabling lung disease related to the concentration of coal dust underground. Most coal mine health experts agree that coal mine health and safety legislation of 1969 and 1977, properly enforced, will significantly reduce this hazard. The legislation imposes a coal dust standard of 2 mg/m³. The standard can be achieved

without undue costs or technological limitations, and many underground mines have reached this standard. Until more experience is gained with workers exposed to the new lower dust levels, the impact of the standard on black lung disease will not be known. Disease in the older workers is largely a reflection of previous, less controlled conditions. Many health experts believe that part of the disability reported by miners is attributable to effects of cigarette smoking, perhaps acting together with coal dust exposures. Thus black lung benefits may be society's compensation to the coal miner as much for the hardships of coal mining as for the disease induced by coal mining itself. In any case, there will be a considerable time lag between achievement of current coal dust standards and the effect of this standard on coal worker's lung disease.

It is important for the coal mining industry — both management and labor — to utilize comprehensive health surveillance techniques for evaluating the health status of coal miners under the new legislation. Is the 2 mg/m³ standard adequate to prevent deterioration of lung function and respiratory health? We do not know, because we have not lived with this standard long enough. If disease prevalence among underground miners will not be reduced, it is important for the industry to have gathered appropriate medical evidence from a surveillance program, to be able to say that the dust standard is or is not adequate for preventing lung disease. Other factors, such as increased smoking among young miners, could be contributing to the maintenance of high disease rates even in the face of improved occupational conditions. Only an adequate surveillance system will allow health experts to separate out these competing risks. In the absence of such information, more costly inappropriate controls could be demanded.

The introduction of diesel engines in underground coal mines may create new health problems. Here again the industry must proceed to monitor underground concentrations of diesel exhaust products before a major commitment to diesels are made. The effort to accumulate well validated data on concentrations of nitrogen oxides and organic aerosols from use of diesel engines in a few test mines will be fully justified when control technologies are subsequently proposed.

The coal mine industry can take measures to minimize underground accidents and meet current coal dust standards without undue costs. Federal legislation and labor awareness of health and safety issues will require these measures. Beyond this, the industry should institute a health surveillance program to determine whether current regulations are adequate for protection of worker health.

Reclamation of Arid Lands from Surface Mining

Surface mining can seriously disrupt natural terrestrial systems, especially in the fragile, semi-arid environment of the northern great plains. The recently passed Surface Control and Reclamation Act of 1977 requires surface mined areas to be restored. In areas with steep slopes where severe erosion can occur, reclamation costs may well be prohibitive. In many other environments, however, reclamation of most surface areas should not be difficult or costly. However, reclamation in arid and semi-arid regions, where much of the easily accessible surface coal in the U.S. is found, presents severe problems. Ecological systems in these areas have required hundreds of years for their development. Limited rainfall and water supplies that are fully spoken for prevent reestablishment of disturbed ecosystems even if costly efforts are taken to do so. In spite of statements from technological optimists, it would be well for the industry to be extremely cautious in allocating major resources to the exploitation of coal fields by surface mining in arid and semi-arid regions. Federal and state legislation and concerns of strong environmental groups will make surface mining in these areas a costly and risky venture.

Surface mining in the Illinois-Indiana coal fields will not create reclamation problems. Mining will compete with intensive farming in these states, and land use controls may place constraints on access to farming regions. The mining industry will have to negotiate with the farming community on these matters.

Surface mining in Appalachian areas will be altogether constrained in terrains with steep slopes. In other places, land reclamation should be relatively easy because of the abundant rainfall and vegetation in Appalachia.

Health Effects of Coal Combustion Products

The air pollutants of principal concern here are sulfur oxides, nitrogen oxides, particulate aerosols, and a few trace elements. There is little disagreement in the health community that existing sulfur oxide standards are necessary for protection of public health, and that high sulfur coal should not be burned without precombustion cleaning or stack gas scrubbing. The 1977 amendments to the Clean Air Act require installation of best available control technology (BACT) on all coal fired units that exceed 25 MW electrical energy. At the present time, BACT means flue gas desulfurization, even if low sulfur coal is used for fuel.

The health community is very concerned with increased utilization of coal in the U.S. Considerable evidence has accrued concerning atmospheric formation and long distant transport of submicronic aerosols from fossil fuel combustion. These aerosols consist of sulfuric acid, acid sulfates and nitrates and organic particles. They are formed in the atmosphere from primary compounds such as sulfur dioxide and nitric oxide in flue exhausts. These compounds are responsible for regional haze formations especially associated with summer-time stagnant air masses. Moreover, evidence is mounting that these aerosols formed in the atmosphere are more of a health hazard than the primary pollutants emitted from the stack.

A variety of adverse health effects have been associated with coal combustion products. These include the following: increased death rates during periods of air stagnation; higher rates of chronic bronchitis and emphysema in more polluted cities; aggravation of asthma and of heart and lung disease on days with greater pollution; increased frequency of acute respiratory infections such as the common cold, sore throat, and chest infections among children living in more polluted cities; diminished lung function among children growing up in polluted cities; some evidence, less firm than for the other health effects, that lung cancer rates are increased by exposure to fossil fuel combustion products.

Acid sulfates and submicronic aerosols probably play a major role in the lung irritation that results in many of the health problems described above. Therefore an energy policy that would cause increased emissions of sulfur oxides and increased atmospheric formation of submicronic aerosols would be vigorously opposed by the health community.

The crucial question is, do present air pollution levels represent a public health hazard? Expert opinion is divided on this question. Some feel that, compared with cigarette smoking, current levels of air pollution present little risk to health and that there is no reason to prevent deterioration of air quality in relatively clean areas, as long as primary air quality standards are not violated. Others believe that any amount of increased air pollution represents some public health risk and that we should require use of the best available control technology everywhere, especially since air pollutants can be transported for hundreds of miles from unpolluted to more polluted areas.

However, even to prevent exceedances of primary air quality standards in many urbanized areas in the face of increased utilization, will require adoption of the following policies (as cited by the federal Committee on Health and Environmental Effects of Increased Coal Utilization): compliance with federal

and state air, water and solid waste regulations, universal adoption and successful operation of best available control technology on new or converted facilities, and judicious siting of coal-fired power plants.

In some areas of the country, where pollutant levels are already at or near the primary air quality standard, increased use of coal may have to be constrained. Such constraints are likely in the large metropolitan areas of the midwest and northeast. If nuclear power is rejected as an energy alternative for these areas, it may be necessary to move towards various forms of precombustion cleaning or even closed cycle combustion of coal in order to limit sulfur oxide and aerosol emissions.

In other areas, such as the southwest, where coal will have to replace natural gas and fuel oil used by utilities, significant increases in SO₂ emissions could present a health, visibility and ecological problem.

Overall, the energy industry will be forced to improve existing sulfur oxide control technologies and will be continuously pushed into utilizing best available control technologies.

Toxic Trace Elements in Coal Combustion Wastes

Trace elements such as arsenic, cadmium, mercury, and radionuclides including uranium 235 and 238 and thorium 232 are present in coal and represent potential hazards to human health. Coal extraction, combustion, and stack gas cleaning effectively concentrates these substances and introduces them into the environment in more concentrated forms than they would appear as a result of natural weathering. The problem then is to dispose of the coal ash and flue gas wastes in such a way that they cannot leach from disposal sites into underground aquifers or surface waterways.

Trace elements can enter the environment prior to coal combustion by runoff from coal mines and coal storage piles, during combustion in atmospheric emissions of volatile elements (especially mercury), and after combustion by runoff from wastes deposited in settling ponds and landfills. Microorganisms in the environment can absorb, concentrate, and transform trace elements into more toxic forms. Trace elements may enter food chains and undergo bioaccumulation in passage through higher forms of life. Of particular concern in this regard are mercury, cadmium and lead.

Atmospheric emissions of trace elements from coal-fired power plants do not add significantly to body stores of these substances. However, some atmospheric trace elements such as manganese and

vanadium are active in the catalysis of SO₂ to acid sulfates and, in this way, may contribute to the respiratory hazards of these coal combustion products. Three elements — arsenic, chromium and nickel — are accepted as being carcinogenic to man. All three of these elements can appear in fly ash leachate, but in unknown concentrations.

The potential for contamination of drinking water supplies by leachates from settling ponds and power plant disposal sites is very real and needs to be carefully monitored. According to the national energy plan, a large number of these disposal sites will be necessary by 1985, when up to 60 million tons of waste will be generated.

Radiation from increased coal combustion does not appear to present a significant public health problem. The average natural background radiation level is 80 to 100 mrem/yr per person (whole body dose), while the corresponding radiation rate associated with increased coal combustion is projected at only 0.007 mrem/yr per person.

Implications of These Constraints for the Energy Industry

During the past 10 years, the energy industry was beset with a formidable array of environmental legislation and regulations that definitely increase the cost of fossil fuel extraction, combustion and waste disposal. Some in the industry consider these costs to be a wasteful allocation of precious resources. This attitude is not only archaic but detrimental to the industry. Society has become sensitized to the social costs of environmental pollution, and it is unreasonable to assume that these sensitivities will be lost. The health and environmental consequences of past practices are too severe to be tolerated.

For the most part, existing control technologies are sufficient to cope with the environmental issues described above. Straightforward application of these technologies should enable the industry to meet occupational health standards, reclamation policies (except in arid regions) and air quality standards even with increased utilization of coal for energy. To do so, however, requires industry to adopt best available control technologies and to make these technologies fully operational.

The longer industry delays, either through court actions or tardiness in introducing best available technologies, the greater will be the potential damage to health and environment, and the greater the public demand for even more stringent regulations and laws.

The energy industry needs the experience of working with the new control technologies. A seri-

ousness of purpose here will buy precious time and public confidence, while overt foot-dragging could cause legislative retribution and further chaos.

The challenge is to convince corporate managers of the seriousness of the environmental issues as-

sociated with energy systems, and to convert these convictions into a vigorous program of environmental hazard containment. This program can most efficiently be developed within the industry, rather than forced upon the industry externally.